AFQTP 3E1X1-17
30 JUN 00

# AIR FORCE

# QUALIFICATION TRAINING PACKAGE

# (AFQTP)

**for**

**HVAC/REFRIGERATION**

**(3E1X1)**

## MODULE 17

## HVAC CONTROL SYSTEMS

# TABLE OF CONTENTS

# MODULE 17

# HVAC CONTROL SYSTEMS



Career Field Education and Training Plan (CFETP) references from 1 Apr 97 version.

OPR: HQ AFCESA/CEOT
(SMSgt Michael R. Shakal)

Certified by: HQ AFCESA/CEO
(Colonel Lance C. Brendel)

**Notice.** This AFQTP is ***NOT*** intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

# AIR FORCE QUALIFICATION TRAINING PACKAGES
**for**
**HVAC/REFRIGERATION**
**(3E1X1)**

## INTRODUCTION

***Before starting this AFQTP,*** refer to and read the "Trainee/Trainer Guide" located on the AFCESA Web site **http://www.afcesa.af.mil/**

***AFQTPs are mandatory and must be completed*** to fulfill task knowledge requirements on core and diamond tasks for upgrade training. ***It is important for the trainer and trainee to understand*** that an AFQTP ***does not*** replace hands-on training, nor will completion of an AFQTP meet the requirement for core task certification. AFQTPs will be used in conjunction with applicable technical references and hands-on training.

***AFQTPs and Certification and Testing (CerTest) must be used as minimum upgrade requirements for Diamond tasks***.

## MANDATORY minimum upgrade requirements:

***Core task:***
AFQTP completion
Hands-on certification

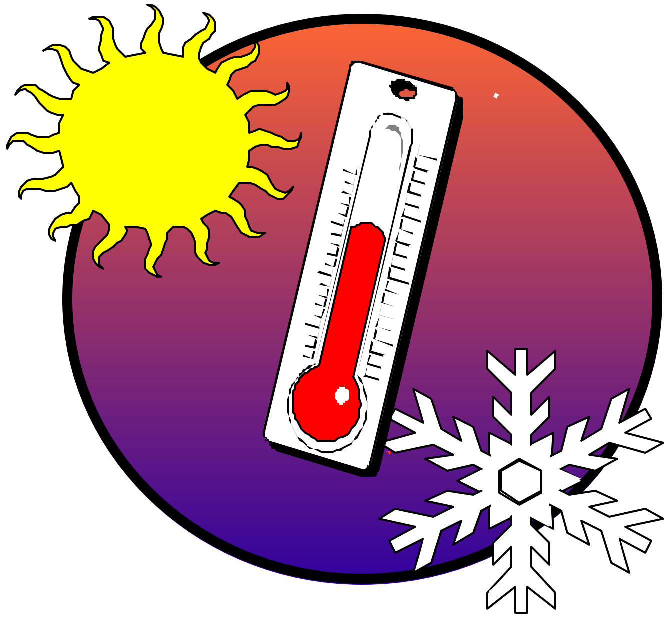
***Diamond task:***
AFQTP completion
CerTest completion (80% minimum to pass)

***Note:*** *Trainees will receive hands-on certification training for Diamond Tasks when equipment becomes available either at home station or at a TDY location.*

***Put this package to use.*** Subject matter experts, under the direction and guidance of HQ AFCESA/CEOT, revised this AFQTP. If you have any recommendations for improving this document, please contact the HVAC/R Career Field Manager at the address below.

HQ AFCESA/CEOT
139 Barnes Dr. Suite 1
Tyndall AFB, FL 32403-5319
DSN: 523-6421, Comm: (850) 283-6421
Fax: DSN 523-6488
E-mail: ceott.helpdesk@afcesa.af.mil

**Notice.** This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.



# REPAIR COMPONENTS

## MODULE 17 AFQTP UNIT 5

### TROUBLESHOOT

### (17.5.1.)

### CORRECT MALFUNCTIONS

### (17.5.2.)

# TROUBLESHOOT

# CORRECT MALFUNCTIONS

## *Task Training Guide*

| | |
|---|---|
| **STS Reference Number/Title:** | 17.5.1. Troubleshoot<br>17.5.2. Correct Malfunctions |
| **Training References:** | • AFJMAN 32-1093; Modern Refrigeration & Air Conditioning; Principles of Refrigeration Control Systems for HVAC; Automatic Controls for Heating and Air Conditioning; Environmental Systems Technology |
| **Prerequisites:** | • Possess as a minimum a 3E131 AFSC. |
| **Equipment/Tools Required:** | • Personnel Protective Equipment<br>• Standard HVAC/R Tool Bag |
| **Learning Objective:** | • Trainee will know the steps to safely troubleshoot and correct malfunctions on HVAC Control Systems. |
| **Samples of Behavior:** | • Trainee will be able to troubleshoot and correct malfunctions on HVAC Control Systems. |
| **Notes:** | |
| • Any safety violation is an automatic failure. | |

## TROUBLESHOOT

## CORRECT MALFUNCTIONS

**Background:** Troubleshooting and correcting malfunctions of control systems is one of the main concerns you will have in your job. In this AFQTP, you will learn about some common problems with pneumatic, electrical, electronic, and direct digital control systems and how to correctly resolve them.

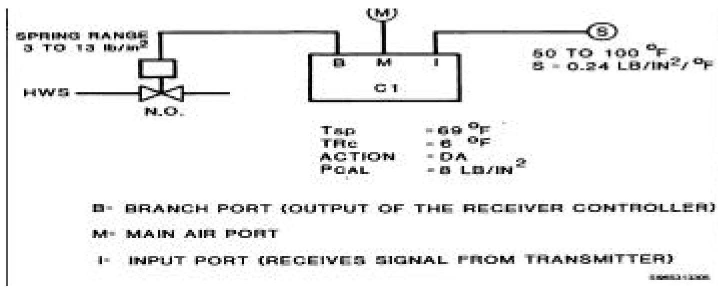



**Figure 1, Pneumatic Control System**

**Pneumatic Control Systems.** We approach troubleshooting of pneumatic controls with a Z to A concept. First, we check the *controlled device* (valve or damper operator/actuator) for proper spring range and lubrication. Next, we check the controller for proper operation. Last, we check the *sensor (transmitter) to see whether it is producing the proper pressure for the temperature measured. Follow these procedures after you have checked the air supply to see whether it is operational. Figure 1 shows a block diagram of a pneumatic Control System. Figure 2 shows a controlled device.

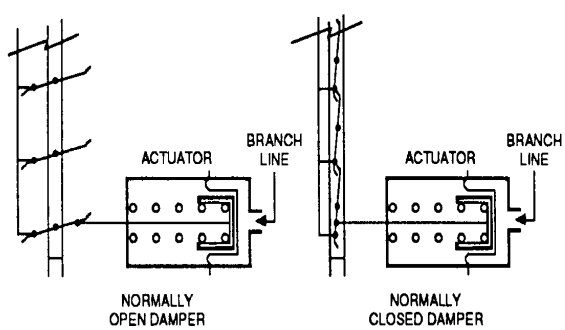



**Figure 2, Controlled Device**

First, let's discuss the procedure for checking a controlled device. As you know, there are many different spring ranges for controlled devices. For you to check these spring ranges, you must have some sort of measurable air supply. One suggestion is to utilize a hand held aspirator like the device used to measure blood pressure. Make sure that the aspirator used has a gauge for pressure, this will aid in recording the pressure. Disconnect the branch line coming from the

**Notice.** This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

controller and attach the aspirator to the controlled device. Pump up the air pressure till the controlled device valve stem starts to move. Record the pressure. Continue to increase the pressure until the controlled device valve stem has stopped and record this pressure. These two pressures are the spring range of the controlled device. The spring range of the actuator restricts movement to the controlled device to within limits. Some typical spring ranges for pneumatic actuators are 3 to 7 psig, 3 to 8 psig, 8 to 13 psig, and 9 to 13 psig. Figure 3 shows an internal view of a controlled device.

**Example:** As you pump the aspirator the valve begins to open at 8 psi, you continue to pump the aspirator and the stem stops at 13 psi. This means your spring range is from 8 to 13 psi. Remember this is an example only and other pressures then what's given may be recorded. The key issue is to know the actual spring range you have.

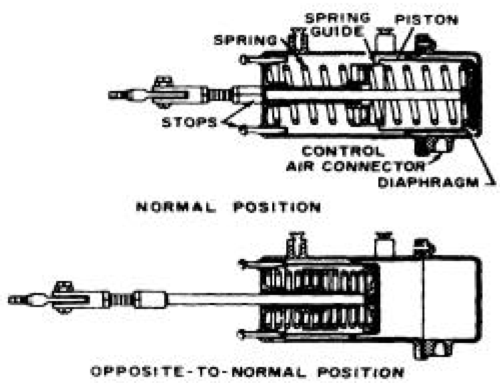



**Figure 3, Internal view of a Controlled Device**

**Don't confuse spring range with pressure range. Pressure range is the change in pressure necessary for the controller output to change over the throttling range. For example, in a 3 to 15 psi system, the pressure range is 12 psi.**

If this is not the spring range you want, you have two options. You can replace the controlled device or spring or you can recalibrate the controller, using the newly found spring range. Reconnect the branch line to the controlled device and move upstream to the controller. The controller, if a thermostat or remote bulb, can be checked as follows:

1. Adjust the set point dial to the ambient-measured conditions.
2. Check the output pressure of the controller. If the pressure is the pressure you want (Pcal), then the controller is in calibration.
3. If the pressure is not the pressure you want (Pcal), refer to the calibration procedures to recalibrate the controller.
4. If you have a single-input receiver controller installed in the system and you need to troubleshoot it, disconnect the sensor and connect a pneumatic simulator to simulate set point and Pcal conditions.
5. Once the simulator is connected, dial in the set point pressure and check the output pressure. It should be Pcal.
6. If the pressure is not Pcal, recalibrate.

7. Once you are sure the controller is in calibration, reconnect the sensor to the proper port.
8. Check the sensor.
9. Use the same pneumatic simulator and disconnect the sensor from the controller.
10. Connect the pneumatic simulator to the sensor.
11. Measure the ambient condition of the sensor.
12. Use following equation to find the pressure that should be coming out of the sensor at the present ambient condition: Pout = SENs (Tm - Tref) +3
13. Example: If a transmitter (sensor) sees a temperature of 80 F, the output pressure is: Pout = .24 (50 degree span of transmitter and produces a signal of 3 to 15 psi) (80-50) + 3 = 10.2 psi
14. If the sensor is producing the correct pressure, reconnect it to the controller and move on to some other area for a problem.
15. If the sensor is not producing the proper pressure, adjust it if the sensor is adjustable.
16. If the sensor is not adjustable, replace it.

- **For a dual-input receiver controller, use the same pneumatic simulator, but use two simulators—one for each sensor. Follow the same troubleshooting procedure listed for the single-input controller.**
- **To get SENs: sensor output span / degree span of sensor (12 / 50 = .24)**

Troubleshooting the adapters (relays) in a system is very simple. First, you must know what the adapter is set up to do. Let's take a reversing relay as an example. To verify that the relay is working correctly, you would have to know the desired output signal for each input signal. In other words, at zero input signal what would my output signal be, and at 25 % of my input signal what would my desired output signal be. This would carry on for 50%, 75%, 100% and the reverse. Remember, for each input you must adjust the relay to produce the required output pressure. If the relay is unresponsive, replace with new relay.

**Electrical Control Systems.** Troubleshooting electrical controls is a process of elimination, starting at the input power source and working through the system until the problem is found. You may find a fuse blown or a burned out controller when you troubleshoot electrical control systems. If you encounter these problems, you must also find out why the fuse was blown or the controller was burned out.

**Two Position Controls.** Two-position controls are some of the simplest controls to check. We'll look at on-off controls both with and without differentials. Your first step in troubleshooting a two-position control *without* a differential is to see that the switch opens and closes at the right points. If you turn the switch to the ON or OFF position, the operating equipment should run with the contacts closed or stop when they open. If you suspect this control of operating improperly, and the rest of the circuit has checked out, then you must check the control.

To start, disconnect the wires from the control, and then connect the ohmmeter between the switch terminals. Turn the switch to the OFF position; contacts will be open inside the switch and the ohmmeter will read infinity, or no continuity. Turn the switch to the ON position; contacts will close, your ohmmeter will read zero (showing there is continuity or a path for electric current). If you don't get a change in reading or the readings are different the control has an internal malfunction. Try holding one of the meter leads on the switch terminal and touching the outside casing of the control; any movement of the needle could mean the switch has shorted out internally to the casing. Replace the switch if you get this reading.

For a control with a differential, first check the operation by raising and lowering its set point to the open and close positions. If you think the control is operating improperly, check it for the same reading you did above, but this time raise or lower the set point more or less than the differential. While you're doing this, you should not get a change of reading until you reach the opposite setting. For example, if a control turns off at 100°F and has a subtractive differential of 20 F, it will start the equipment at 80°F. With the set point at 100°F and the meter leads on the terminals, you then lower the set point until the meter reading goes from infinity to zero. The meter should not go to zero until you reach the ON position. If it does, the control has an internal malfunction. Always verify the type of control and check manufacturer's instructions when troubleshooting controls.

**Proportional Controls.** A proportional control (Figure 4) is when a controlled device is positioned proportionally in response to changes in a controlled variable. In troubleshooting a proportional control, make sure the modulating motor moves the damper or valve fully open or fully closed at the proper setting. If the motor runs in the right direction when you adjust the set point, you can assume the control is operating properly. If it runs in the wrong direction, reverse the two end wires to the potentiometer in the control. Observe the motor's action to see if it stabilizes the damper or valve.

If you suspect a proportioning control is operating improperly, you can check it further with an ohmmeter. Disconnect the wires from the control (terminals W, R, B) and connect the ohmmeter leads to terminals W and B. The reading should be about 135 ohms—standard on most proportioning controls (check the manufacturer's specification). If you get a reading of zero ohms or infinity, you've found the problem—bad potentiometer. If your reading is within the 135 ohms, then connect one lead to terminal R and the other to W or B. Now turn the adjustment screw to move the set point to the opposite end of the other lead. Again you should read 135 ohms. Slowly lower the control's set point, watching the reading. The resistance should drop slowly until you reach the opposite end, where your reading will be zero ohms. If the reading drops while you are lowering the set point before reaching the other side, the potentiometer is bad. Remember to handle these controls and all controls carefully. Always follow the manufacturers instruction's for any control you are troubleshooting.

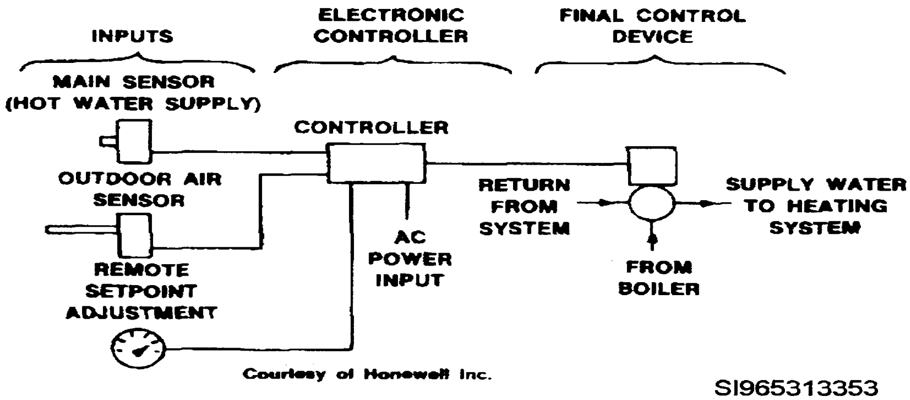



Figure 4, Proportional Control System

**Electronic Control Systems.** This area provides information about electronic control systems used on HVAC equipment. An electronic control system has a sensor, a controller, and a controlled device, (See Figure 5 below). The type of power for an electronic control system is low amperage or low voltage electricity (normally 4 to 20 milliamps dc or 0 to 15 volts dc).

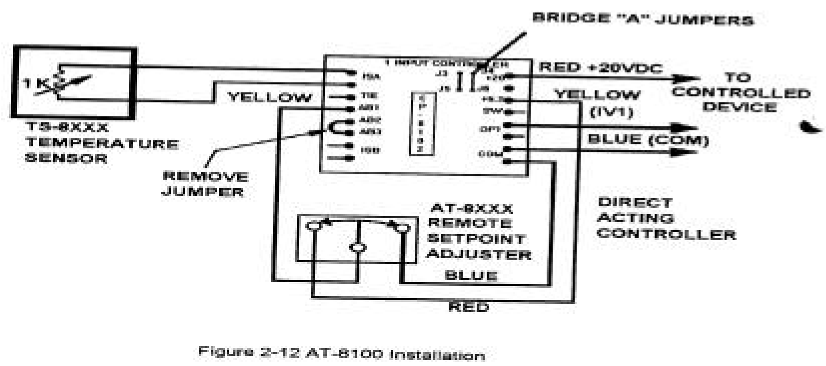
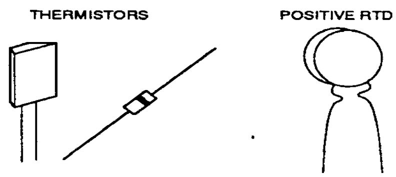



Figure 5, Electronic Control System

**Sensors.** A sensing element gives a controller information on changing conditions. Analog sensors are used if the conditions, such as pressure or temperature, are continuously changing. Some electronic sensors use an inherent attribute of their material, such as wire resistance, to provide a signal and can be connected directly to the electronic controller. Other sensors require conversion of the sensor signal to a type or level that can be used by the controller. For example, a sensor that detects pressure needs a transducer (also called a transmitter) to convert the pressure signal to a voltage that the controller can use.

**NOTE**

**A transmitter when referred to in electronics is a device that converts one energy form to another or amplifies an input or output signal.**




These sensors, in most cases, are resistors that change their resistance as the measured variable changes. The most common variables are temperature and humidity. Unlike pneumatic sensors, an electronic sensor cannot be connected to more than one controller. Electronic sensors must be disconnected from the controller before their resistance can be measured.

**Electronic Temperature Sensors** are made of special materials that change resistance when the temperature changes. They are commonly called resistance temperature devices (RTD) and have no moving parts and usually have no calibration adjustment. Most sensor materials increase their resistance as the temperature increases, and the reverse is true as the temperature decreases.

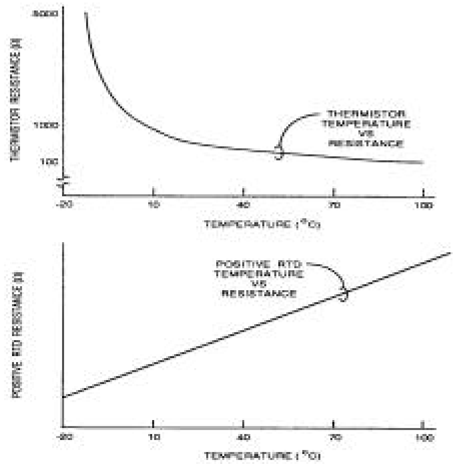



**Figure 6, Typical Sensor Resistance Graphs**

A few manufacturers use sensors called “thermistors” that decrease their resistance as the temperature increases. The resistance of any sensor can be predicted by this equation:

Rs = [(Tm – Tref) x ROC] + Rref

*Where:*

Rs = Sensor resistance

Tref = Reference temperature: specified by the sensor manufacturer

Tm = Temperature measured

ROC = Rate of change, specified by the sensor manufacturer

Rref = Resistance of the sensor at the reference temperature, specified by the manufacturer

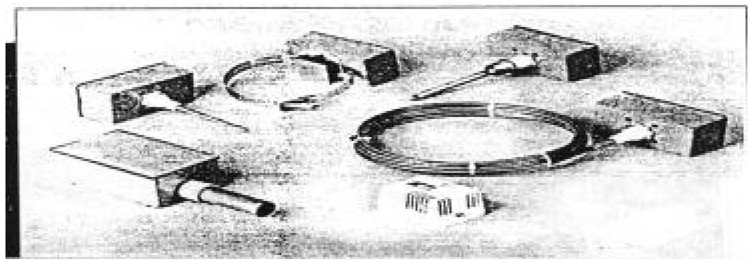
Figure 6 shows the relationship between temperature and sensor resistance for Thermistors and RTDs.

For example, a Barber Colman sensor (made by Balco) has a 1,000 ohms reference resistance or Rref at 70°F that is the reference temperature or Tref, and it has a rate of change of 2.2 ohms per degree F. To find the resistance at 80°F, substitute in the above equation:

Rs = [(80 – 70) x 2.2] + 1,000 ohm     Rs = 1,022 ohm

**Temperature sensors** come in many shapes and sizes, depending on the application (See Figure 7). If you have doubt that a sensor is working use the equation along with checks at several different temperatures. You can achieve this by using a good digital thermometer, ohmmeter, and steady way of changing the temperature surrounding the sensor, i.e., increase or lower room temp, hold in hand, or blow warm or cold air on sensor and thermometer. Manufacturers of control systems sometimes supply a performance chart of temperature to resistance values.

**Figure 7, Some Typical Sensors**



**Humidity sensors** are unique components, and it is very important that specific manufacturer instructions be followed. Humidity sensors are sensitive to dirt and vibration, and they tend to drift out of calibration with time. For this reason they must be handled carefully and their calibration checked frequently. A good way to find out if your humidity sensor is out calibration is to place a calibrated humidity/temperature recorder or hygrometer in the room (near the sensor if the sensor is located in the room). Let it take readings for at least 24 hours, then compare the set point to what you have on the humidity/temperature recorder chart. For faster checks and corrections use a high quality hand held hygrometer and make adjustments according to the manufacturer's recommendations. Figure 8 and 9 show several versions of Humidity Sensors.

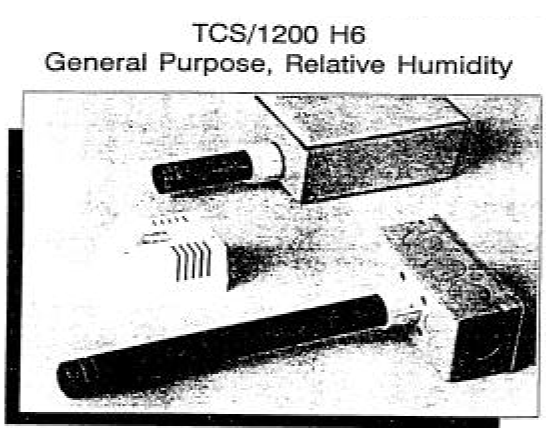



**Figure 8, Humidity Transmitters**

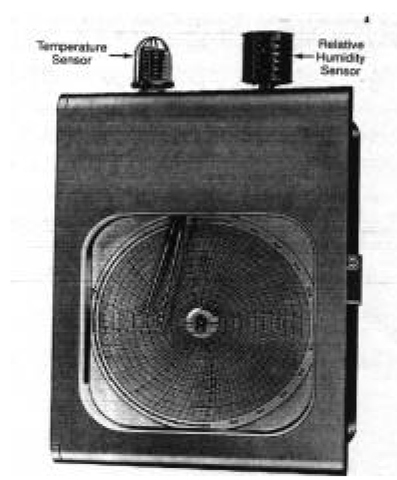



**Figure 9, Humidity Sensor**

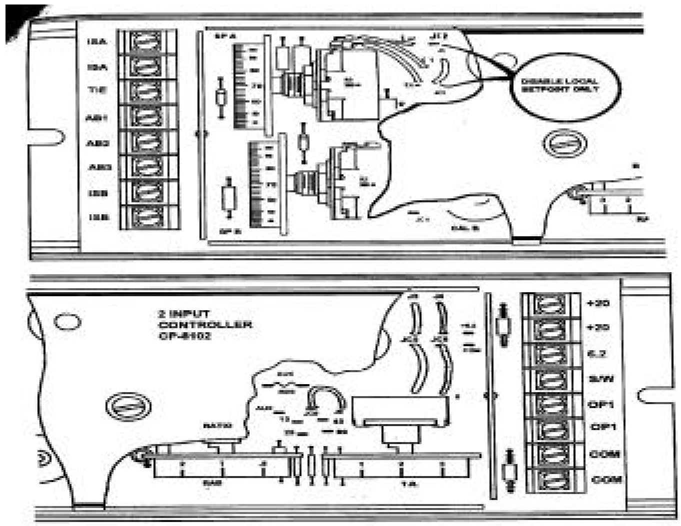



Figure 2-8 Drawing of the CP8102

**Figure 10, Electronic Controller**

**Electronic Controller.** The electronic controller (Figure 10) receives a sensor signal, amplifies and/or conditions it, compares it with the set point, and derives a correction if necessary. This is called the input signal. The output signal typically positions a motor actuator. Electronic controllers are categorized by the type or types of inputs they accept such as temperature, humidity, or enthalpy.

To test electronic controllers you must first know the sequence of operation (how and what the system is designed to do). The reason behind this is you would be hard pressed to find a single controller that can do three different tasks such as temperature, humidity and enthalpy all under one cover. So chances are that one controller will be working in conjunction with at least one or two more controllers. After you know the sequence of operation you can write down the ambient conditions, calculate inputs and outputs, and compare them to what the system is actually doing. Questions to ask yourself may be “are the controllers calling for heating or cooling?”, “should the humidifier be ON or OFF at this time?”, “what position should my dampers be in at this moment?”. There are plenty more questions that could be asked, but hopefully you get the point. If the ambient conditions don’t match up with the positions or operations of the controller, you must systematically troubleshoot the control system down to the actual controller causing the problem. Use manufacturer’s guides and specifications for the type of controls you are working on.

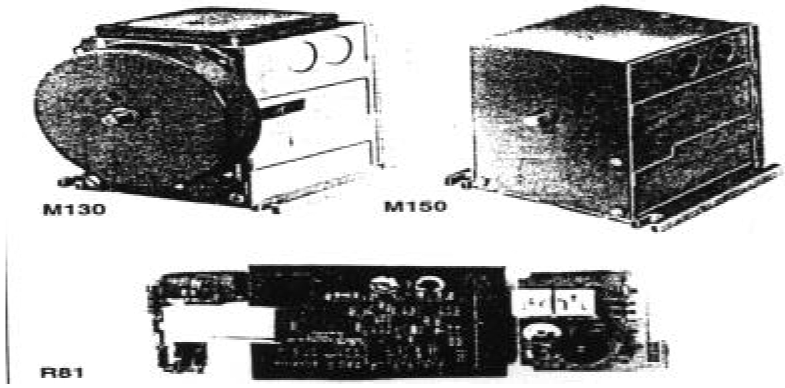



**Figure 11, Electronic Control Devices**

**Electronic Control Device (Figure 11).** Actuators, relays, and transducers are output devices that use the controller output signal (voltage, current, or relay contact) to do a physical function on the final control element such as starting a fan or modulating a valve. Actuators can be divided into devices that provide two-position action and those that provide modulating action. If you are experiencing problems with the control device you must first make sure your controller is signaling for the device to start or modulate. Next, you must know what output from the controller you're looking for; milliamps (mA), volts (V-OUT), pneumatic pressure (P-OUT). If you are receiving the specified signal and the control device still is not operating, you must then troubleshoot the device. For electronic devices you must rely upon your electrical troubleshooting knowledge. For mechanical problems you must use your problem solving skills.

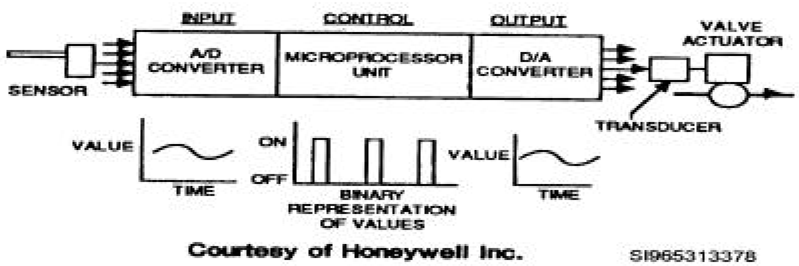



**Figure 12, Typical Direct Digital Controller**

**Direct Digital Control.** A direct digital controller receives electronic signals from sensors, converts electronic signals to numbers, and does mathematical operations on these numbers inside the computer (See Figure 12). The output from the computer takes the form of a number, and can be converted to a voltage or pneumatic signal to operate the actuator. The digital controller must sample its data because the computer must have time for other operations besides reading data. If the sampling interval for the digital controller is chosen properly, no significant degradation in control performance will be seen due to sampling. See figure 13 for typical sampling scheme.

**Note:**
Sampling means that the computer periodically reads all inputs, recalculates the program using new data, and adjusts the outputs accordingly.

Troubleshooting and correcting malfunctions with DDC can range from easy to difficult because of the many systems currently on the market. To add to this, manufacturers have custom made software to fit a particular building or special application. Digital controllers are conservatively designed and often incorporate self-checking features so they notify the operator immediately if anything goes wrong. Input and output circuits are filtered and protected from extraneous signals to assure reliable information to the processor. Any troubleshooting of the microprocessor should be done with the manufacturer's technical guidance for the system having difficulties.

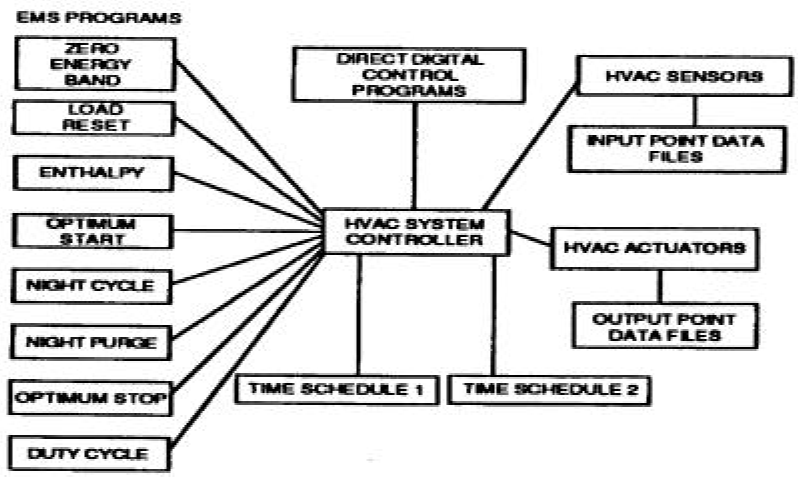



**Figure 13, Typical Sampling Scheme**

# Review Questions

## TROUBLESHOOT
## (3E1X1-17.5.1.)

## CORRECT MALFUNCTIONS
## (3E1X1-17.5.2.)

| Question | Answer |
|---|---|
| 1. Troubleshooting of pneumatic controls should be approached from what concept? | a. Z to A concept<br>b. A to Z concept<br>c. 1,2,3 concept<br>d. 3,2,1 concept |
| 2. What should be checked first when troubleshooting a pneumatic system? | a. The air supply<br>b. Spring Range<br>c. Controller<br>d. Transmitter |
| 3. Where should the aspirator hose be connected to supplement as a source of air supply to check the spring range of a controlled device? | a. Diaphragm of the controlled device.<br>b. In-line connection of the controlled device.<br>c. Branch line connection of the controlled device.<br>d. Branch line connection of the valve stem. |
| 4. What are some of the typical spring ranges of a controlled device? | a. 3 to 7 psig, 3 to 8 psig, 8 to 13 psig, and 9 to 13 psig<br>b. 1 to 3 psig, 6 to 12 psig, .5 to 7.5 psig and 13 to 18 psig.<br>c. Low psig., med. Psig., high psig<br>d. All of the above. |
| 5. If you have a single-input controller installed in the system and you need to troubleshoot it, you should ___________. | a. Connect the sensor and disconnect a pneumatic simulator to simulate set point and Pcal conditions.<br>b. Reconnect the branch line to the controlled device.<br>c. Disconnect the sensor and connect a pneumatic simulator to simulate set point and Pcal conditions.<br>d. Connect the hydraulic simulator and look for leaks. |
| 6. When troubleshooting a dual-input receiver controller how many pneumatic simulators | a. Two simulators; one for each sensor.<br>b. Three simulators; one for each sensor. |

| Question | Answer |
|---|---|
| would you need? | c. Four simulators; one for each sensor.<br>d. One simulator; for the main sensor. |

# Review Questions

## TROUBLESHOOT
## (3E1X1-17.5.1.)

## CORRECT MALFUNCTIONS
## (3E1X1-17.5.2.)

| | |
|---|---|
| 7. What is the first thing you should know before troubleshooting adapters (relays) such as reverse relays? | a. Output pressure is correct.<br>b. What the adapter is set up to do in the system.<br>c. Modulating motor moves the damper.<br>d. Typical spring range. |
| 8. In troubleshooting a two-position control without a differential you should first see that the _________. | a. Switch opens and closes at the right points.<br>b. Switch stays closed.<br>c. Controller is present.<br>d. Contacts are open. |
| 9. How would you test with a ohmmeter to see whether or not a two position control switch is shorted out internally to the casing? | a. Hold one lead on the switch terminal and touch the other on the inside casing of the control.<br>b. Hold one ohmmeters lead on the switch terminal and touch the other on the outside casing; any movement of the needle could mean the switch is good.<br>c. Hold one ohmmeters lead on the switch terminal and touch the other on the outside casing; any movement of the needle could mean the switch is bad.<br>d. Hold one lead on the inside casing, any movement of the needle the switch is bad. |
| 10. In troubleshooting a two-position control with a differential, if a control turns off at 100°F and has a subtractive differential of 20°F, at what temperature should the equipment start? | a. 90°F<br>b. 80°F<br>c. 70°F<br>d. 79°F |
| 11. In troubleshooting a proportional control, you should make sure the modulating motor moves the damper or valve ___________. | a. Fully open and fully closed at the proper setting.<br>b. Fully closed at the proper setting.<br>c. Half open and fully closed at the proper setting.<br>d. None of the above. |

# Review Questions

## TROUBLESHOOT
## (3E1X1-17.5.1.)

## CORRECT MALFUNCTIONS
## (3E1X1-17.5.2.)

| | |
|---|---|
| 12. What should you do if a proportional control motor runs in the wrong direction? | a. Replace the two end wires to the potentiometer in the control circuit.<br>b. Replace proportional control motor.<br>c. Reverse the two end wires to the potentiometer in the control circuit.<br>d. Adjust set point. |
| 13. If you receive a reading of 135 ohms from your ohmmeter while testing between terminals W and B on a proportional control motor, the motor should be___________. | a. discarded or thrown away.<br>b. assumed good.<br>c. repaired.<br>d. used for parts. |
| 14. If you get a reading of zero or infinity on your ohmmeter while testing between terminals W and B on a proportional control motor, what is the most probable cause of the problem? | a. Meter leads bad<br>b. Bad potentiometer<br>c. Motor shorted<br>d. Open capacitor |
| 15. What are the three components that make up an electronic control system? | a. Set point adjustment, Heating system and ac power input.<br>b. Output, digital controller and control device.<br>c. Sensor, electronic controller and final control device.<br>d. Floor sensor, manual controller, and cold water supply. |
| 16. The power source for an electronic control system is __________. | a. Low amperage (4 to 20 mA dc) or low voltage (0 to 15 volts dc).<br>b. High amperage (4 to 20 mA dc) or high voltage (0 to 15 volts dc).<br>c. Low amperage (4 to 20 mA dc) or high voltage (0 to 15 volts dc).<br>d. High amperage (4 to 15 volts dc) or low voltage (4 to 20 mA dc). |
| 17. What type of electronic sensors are used if conditions, such as pressure or temperature, are continuously changing ? | e. Digital sensors<br>f. Analog sensors<br>g. Manual sensors<br>h. Voltage sensors |

# Review Questions

## TROUBLESHOOT
## (3E1X1-17.5.1.)

## CORRECT MALFUNCTIONS
## (3E1X1-17.5.2.)

| | |
|---|---|
| 18. What is a RTD? | a. Resistance temperature device that changes resistance as the temperature increases.<br>b. Resistance temperature device that changes resistance as the temperature decreases.<br>c. Resistance temperature device that changes resistance as the temperature changes.<br>d. Radioactive Temperature Detector. |
| 19. What is the difference between a thermistor and an RTD? | a. Thermistors increase their resistance as the temperature increases.<br>b. Thermistors decrease their resistance as the temperature increases<br>c. Thermistors decrease their resistance as the temperature decreases.<br>d. Thermistors increase their resistance as the temperature decreases. |
| 20. Humidity sensors are sensitive to dirt and vibration, and they do not tend to drift out of calibration. | a. True<br>b. False |

**TROUBLESHOOT**
**(3E1X1-17.5.1.)**

**CORRECT MALFUNCTIONS**
**(3E1X1-17.5.2.)**

| **Performance Checklist** | | |
|---|---|---|
| **Step** | **Yes** | **No** |
| 1. Demonstrate troubleshooting a pneumatic control system. | | |
| 2. Identify malfunctioning components. | | |
| 3. Demonstrate troubleshooting a electrical control system. | | |
| 4. Identify malfunctioning components. | | |
| 5. Demonstrate troubleshooting a electronic control system. | | |
| 6. Identify malfunctioning components. | | |
| 7. Demonstrate troubleshooting of direct digital control system. | | |
| 8. Identify malfunctioning components. | | |
| 9. Utilized necessary safety precautions to prevent personal injury or damage to control systems. | | |

**FEEDBACK:** Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the mind of both the trainee and trainer.

# Air Force Civil Engineer

## QUALIFICATION TRAINING PACKAGE (QTP)

## REVIEW ANSWER KEY

**For**

**HVAC/REFRIGERATION**

**(3E1X1)**

## MODULE 17

## HVAC CONTROL SYSTEMS

**Notice.** This AFQTP is *NOT* intended to replace the applicable technical references nor is it intended to replace hands-on training. It is to be used in conjunction with these for training purposes only.

# TROUBLESHOOT
# (3E1X1-17.5.1.)

# CORRECT MALFUNCTIONS
# (3E1X1-17.5.2.)

| Question | Answer |
|---|---|
| 1. Troubleshooting of pneumatic controls should be approached from what concept? | a. Z to A concept |
| 2. What should be checked first when troubleshooting a pneumatic system? | a. The air supply |
| 3. Where should the aspirator hose be connected to supplement as a source of air supply to check the spring range of a controlled device? | c. Branch line connection of the controlled device |
| 4. What are some of the typical spring ranges of a controlled device? | a. 3 to 7 psig, 3 to 8 psig, 8 to 13 psig, and 9 to 13 psig |
| 5. If you have a single-input controller installed in the system and you need to troubleshoot it, you should _____________. | d. Disconnect the sensor and connect a pneumatic simulator to simulate set point and Pcal conditions |
| 6. When troubleshooting a dual-input receiver controller how many pneumatic simulators would you need? | a. Two simulators; one for each sensor |
| 7. What is the first thing you should know before troubleshooting adapters (relays) such as reverse relays? | e. What the adapter is set up to do in the system |
| 8. In troubleshooting a two-position control without a differential you should first see that the _____________. | a. Switch opens and closes at the right points |
| 9. How would you test with a ohmmeter to see whether or not a two-position control switch is shorted out internally to the casing? | f. Hold one ohmmeter lead on the switch terminal and touch the other on the outside casing; any movement of the needle could mean the switch is bad |
| 10. In troubleshooting a two-position control with a differential, if a control turns off at 100°F and has a subtractive differential of 20°F, at what temperature should the equipment start? | b. 80°F |
| 11. In troubleshooting a proportional control, you should make sure the modulating motor moves the damper or valve ____________. | a. Fully open and fully closed at the proper setting |
| 12. What should you do if a proportional control motor runs in the wrong direction? | c. Reverse the two end wires to the potentiometer in the control circuit |

## TROUBLESHOOT
## (3E1X1-17.5.1.)

## CORRECT MALFUNCTIONS
## (3E1X1-17.5.2.)

| | |
|---|---|
| 13. If you receive a reading of 135 ohms, from your ohmmeter, while testing between terminals W and B on a proportional control motor, the motor should be ___________. | b. Assumed good |
| 14. If you get a reading of zero or infinity on your ohmmeter while testing between terminals W and B on a proportional control motor, what is the most probable cause of the problem? | b. Bad potentiometer |
| 15. What are the three components that make up an electronic control system? | c. Sensor, electronic controller, and final control device |
| 16. The power source for an electronic control system is __________. | a. Low amperage (4 to 20 mA dc) or low voltage (0 to 15 volts dc) |
| 17. What type of electronic sensors is used if conditions, such as pressure or temperature, are continuously changing? | d. Analog sensors |
| 18. What is a RTD? | e. Resistance temperature device that changes resistance as the temperature changes |
| 19. What is the difference between a thermistor and an RTD? | b. Thermistors decrease their resistance as the temperature increases |
| 20. Humidity Sensors are sensitive to dirt and vibration, and they do not tend to drift out of calibration. | c. False. |